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AUTOMATIC CONTROL OF TOWN GAS CHARACTERISTICS. By K. A. Steele

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Editorial

Gas and the Industrialist

IN this issue we are publishing a paper by Mr. W. A. Lloyd-Dodd, Industrial Gas Officer of the Southern Gas Board, entitled 'Efficiency and Economy,' which sets out some of the problems to be solved by the industrial gas engineer. The exact meaning of the word efficiency is often difficult to define, since it is capable of variations when applied to plant under differing conditions. Thermal efficiency might be considered regrettably low to a fuel technologist when applied to certain types of plant, but to the heat treatment engineer this might seem of little consequence when other factors of greater importance to him are quite satisfactory. The ease of handling of the products undergoing heat treatment, the uniformity of heating inside the furnace, the small proportion of inferior final products and the improved conditions of working may be of far greater importance to the industrialist than either thermal efficiency or even the cost of the fuel itself. Production efficiency is, therefore, of the utmost importance. If economy in fuel expenditure can also be included, the incentive to change from an existing fuel to gas firing will be all the greater. A third aspect of efficiency is how the use of any particular fuel affects the indigenous fuel resources of the country. This is much more difficult to put over to the large scale fuel user, since a direct monetary advantage can seldom be put forward in favour of using a fuel derived from indigenous sources in preference to an imported fuel, other things being equal. Gas, however, conforms to all three aspects of efficiency and combines with them other intangible advantages of value to the industrialist.

The industrial gas engineer will be well informed of all the industries operating in the area of which he is in charge and will have a good working knowledge of the various processes involved. He should be capable of designing a furnace which will carry out the process work by gas firing at least equally well to that being performed by a crude fuel such as coal or by one of the competitive refined fuels available. His knowledge of thermal engineering will enable him to put forward suggestions for a reduction in overall heat expenditure, but his knowledge of mechanical engineering will enable his furnace design to fit into the continuous production line. Such a furnace must be mechanically and thermally reliable and must be able to stand up to long periods of operation without the need for shutting down for relining or the cleaning of the burners. The importance of gas to the industrialist is immediately apparent, for gas can satisfy all these conditions and is at the same time made from largely home produced fuel.

There are occasions when, at first sight, the price of gas might seem to be an impassable obstacle to its adoption by industry, but further examination frequently reveals unsuspected advantages; and the fact that the use of gas is increasing goes far to confirm its real value as a fuel. With new types of gas production plant being developed, the price industry will have to pay for its gas should markedly decrease. This and the great efforts being made by the gas industry to reduce the total sulphur content will greatly widen the appeal of this most flexible and easily handled fuel.

EFFICIENCY & ECONOMY

By

W. A. Lloyd-Lodd,

B.Sc., M.Inst.F.

INDUSTRIAL GAS OFFICER,
SOUTHERN GAS BOARD

MUCH has been said and written in recent years about fuel efficiency, fuel economy, the national interest, the interest of the consumer, atmospheric pollution, the future or lack of future of the gas industry and a host of related and sometimes irrelevant subjects. This paper represents an attempt to put some of this material into reasonable perspective as much for the benefit of an industrial gas engineer as for the purpose of presenting it to others as a survey of the effects upon the sale of gas of the interaction of these various aspects of the national fuel scene. The first step seems to be to differentiate clearly between efficiency and economy. The former may be used to sell one piece of plant as compared with another but the latter is essential to sell gas to industry.

Pitfalls

Earlier this year Patrick[1] discussed the variety of meanings attached to the word 'efficiency' when it is used to describe the performance of fuel using apparatus, and outlined some of the pitfalls which account for it being one of the most misused words in technical and semi-technical discussion. Essentially he distinguished between thermal efficiency, fuel efficiency and overall production efficiency, and fully discussed the variety of possible interpretations which could be given to the thermal efficiency of even one simple appliance. It is proposed here to consider efficiency under the three headings of thermal efficiency, fuel efficiency and national fuel efficiency. Overall production efficiency is, within the context of this paper, a matter of economy rather than of efficiency.

Thermal efficiency, or the heat transferred to the work expressed as a percentage of the total heat supplied, is, in spite of its popularity, a criterion of limited value. It is, however, a useful measure for comparing the performance of similar systems. Much has been achieved by designers in recent years in improving the thermal efficiency of plant. A major contribution has been made by the increased application of regenerative and recuperative methods to the recovery of heat from both flue gases and stock and of recirculation of the waste gases. The domestic gas fire, a good pattern of which a few years ago had a room-heating efficiency of only 45%, is a simple example. Now 60 to 65% is to be expected. Much still remains to be done and the technology of waste heat recovery from comparatively small scale processes operating at 1,000°F. and below merits much greater attention than it has received hitherto.

Improved designs of liquid heating tanks have shown remarkable increases in efficiency. Details of a test have been quoted[2] where comparatively simple and inexpensive modifications to a water heating tank raised the thermal efficiency during heating up from 31% to 57%. The development of tubular immersion heating, too, permits the attainment of efficiencies of 60 to 65% for the heating of liquids and the melting of light alloys. The increasing use of insulating refractories in furnace construction has also made substantial contributions by reducing not only the heat transmitted through the structure but also the heat storage. The latter point is particularly important with intermittent furnaces. A case has been described[3] where two annealing furnces, similar but for the extensive use of insulating refractories in one, were operated for the same duty. That employing insulating refractories in its construction used only 80% of the gas required per lb. of steel by the other in a normal week's working. The thermal efficiency of processes can be improved not only by improved design of plant but also by intelligent supervision, the use of trained operators and the provision of adequate instrumentation.

The operation of plant at a fraction of its rated capacity is a frequent source of fuel wastage as is the use of higher temperatures than are required for the process. It has been calculated that a bad boiler fireman can waste the output of a skilled miner, and we have certainly lagged behind many other countries in the qualifications we have demanded from, and the status we have given to, a boiler or furnace operative. This applies particularly to the use of solid fuel. Instrumentation, in itself, is no cure for fuel wastage. Correct instrumentation and its intelligent interpretation is essential, but without instruments it is seldom possible for high operating efficiencies to be attained, and, more important, maintained.

A definition of fuel efficiency used for practical purposes in industry is the quantity of heat used per unit of production and is employed as the measure of the performance of equipment.

Implications

The term, national fuel efficiency, however, has much wider implications relating as it does to the efficient use of the nation's fuel resources for any particular purpose. Included, therefore, must be the efficiency of conversion of the primary into the secondary fuels and the efficiency of their distribution. The difficulties in the way of its true assessment are reflected in the reluctance of successive Governments to frame a National Fuel Policy other than on the basis of expediency. What is more, the difficulties are increasing with the growing use of an imported fuel, oil, both as straight fuel and as feedstocks for town gas manufacture, and with the development of nuclear power. Even omitting the complications of oil and nuclear electricity, comparisons are not easy except for specified applications such as, for example, the relative national fuel efficiencies of modern coal, coke, gas and electric fires for room heating. If, and even this is subject to heated

From a paper to the London and Southern Section, I.G.E., October 21.

argument, the convention of attributing equal production efficiencies of gas and coke is accepted and the production efficiency figures used by the Simon Committee are taken[4], national fuel efficiencies of modern appliances can be compared roughly as shown in Table 1.

TABLE 1

	Production and distribution efficiency	Appliance efficiency	Fuel efficiency
Coal fire ..	100	35	35
Coke fire ..	73	40	29
Gas fire ..	73	60	44
Electric fire ..	18	100	18

Lyle[5] attempted to assess the overall fuel efficiency of coal utilisation in this country by estimating the division of our coal consumption between four major uses and broadly assessing the overall efficiency of use in each class. His four categories and estimated efficiences are summarised in Table 2.

TABLE 2

Method of use	Efficiency of use %
Conversion to, and utilisation as, gas and coke	38
Combustion raw for industrial heating	23
Combustion raw for commercial and domestic heating	17
Conversion to, and utilisation as, power	2.2
Total use of coal	15

However one may disagree on points of detail, there is little doubt that these figures, particularly the overall efficiency of 15%, are of the right order of magnitude. They have been quoted to make the following points:

1. An increase in the overall figure from 15 to 16% would mean a yearly saving of nearly 2 mill. tons of coal, equivalent to the output of 3,000 miners.

2. Improvements in the thermal efficiency of individual existing processes, important though they may be parochially, can have little effect on such a low national figure. A more fundamental approach is necessary.

3. The replacement af raw coal in industrial, commercial and domestic heating furnaces by gas and coke would reduce our coal requirements for these purposes by 45% or about 35 mill. tons per year.

A specific example of what can be done is the case of a twin sided frame heating furnace on Tyneside. When coal fired, its consumption averaged 30 tons per week. On conversion to gas, the fuel consumption for the same output was 1,800 therms per week. This is equivalent to 12 tons of coal per week, using the Ministry of Power's gas:coal equivalent figure of 150 therms per ton. This particular conversion represented a coal saving of 18 tons per week or 60%.

The industrialist, however, has to look at things somewhat differently because the financial aspects must also be considered. This is where economy starts to part company from efficiency because it is an unfortunate fact—unfortunate not only for the gas industry but for the nation—that the value of fuel efficiency is much less to the individual firm or person than it is to the nation.

Lack of incentive. The main reasons for these differences in outlook are:

a. Ignorance of possible savings and advantages.

b. The lingering effects of previous conditions when fuel was both plentiful and cheap. Even now fuel costs are still under 5% of the total production costs of most industries. In many cases they are only 1 or 2%.

c. The amount of capital available has been limited and its investment in means of directly increasing production have seemed more attractive.

d. High rates of taxation have also made investment in fuel saving appliances less attractive.

e. The higher price per therm of the fuels which can be employed most efficiently. This is discussed in further detail later in the paper.

Encouragement

It must be admitted that the government has taken some steps to encourage the efficient use of fuel. The National Industrial Fuel Efficiency Service was set up with the backing of the major fuel industries to carry on and expand the work of the Fuel Efficiency branch of the old Ministry of Fuel and Power and case histories published demonstrate the scope for savings. Courses have been initiated for the training of stokers and attempts have been made to raise their status. There are, too, the Government Loan Scheme for fuel saving equipment and The Investment Allowances (Fuel Economy Plant) Order 1956 which amended the Finance Act so as to provide investment allowances on the installation of prescribed fuel saving plant. But because applications are assessed on the coal saving to be achieved, there is a built-in discrimination in both cases in favour of fuel oil conversions. This arises because the coal-saving resulting from a conversion must, in the case of gas and electricity, be debited with the coal required to produce these fuels.

In the application of both schemes, the gas:coal equivalent figure used by the Ministry of Power is 150 therms = 1 ton, which has been the subject of criticism because it is based on the premise that coke is simply a by-product and that the efficiency of gas production is 50%. On the other hand it has to be remembered that 150 therms per ton is twice that which is obtained from conventional carbonising plants. Loans on the strength of coal savings from improvements in gas fired plant and coal to gas conversions have, however, been granted. Examples of the former include the installation of a new gas fired tunnel kiln for wall tiles to replace an old and less efficient plant, originally converted from producer gas, and the application of immersion tubular heating and thermostatic control to a battery of plating tanks with inferior heating systems. Although there are numerous examples to prove that even at the Ministry's gas:coal equivalent figure substantial savings can be obtained from plant conversions to gas, it is difficult to understand why the Investment Allowances Order discriminates more directly and deliberately against gas by excluding it entirely from the types of plant prescribed.

More recently there has been the Thermal Insulation (Industrial Buildings) Act, 1957. Here indeed is a case where ignorance of the potential savings has been the cause of much wasted fuel. A factory with a roof area of 100,000 sq. ft. of corrugated asbestos—assuming three shift working and a heating plant efficiency of 70%—requires the equivalent of some 670 tons of coal each winter to make good the heat loss through the roof. With the roof lined with ½ in. insulating board this figure would be reduced to about 155 tons. This is a reduction of 515 tons per heating season which represents quite a financial saving whatever the fuel used. Obviously the roof insulation costs money, say 2s. 0d. per sq. ft. fixed, or £10,000, but what is not always appreciated is that the capital cost of the heating installation required for the smaller heat load will be reduced by a similar amount. Cases have been known where the capital saving on the heating installation has exceeded the cost of the roof insulation.

Selective

These steps, however, only touch the fringe of the problem and will make little difference to the overall efficiency of use of each form of fuel. It would seem that only substantial increases in the costs of all fuels are likely to be effective and this would

have to be done selectively, presumably by taxation, if it was desired at the same time to make any big improvement in Lyle's figure for the overall efficiency of our use of coal. This form of solution, which imposes fuel prices, would, however, bring many other problems in its train, and, since there is no sign of the constructive national fuel policy necessary to utilise such solutions, it is not proposed to discuss them in detail.

Price factor. An important aspect of the lack of incentive towards national fuel efficiency is that the most efficient fuel from the national point of view is also one of the most expensive. Gas may be the ideal fuel for many purposes both to the engineer and to the nation but its selection must be economic to the industrialist if the expansion of industrial sales of gas are to continue or even for existing loads to be retained. The price of gas has risen since the war much more steeply than those of its 'convenient fuel' competitors, oil and electricity. Since 1949 the increase is of the order of 61% compared with figures of 32% for oil and 28% for electricity. Many explanations have been advanced for this disturbing fact and among the most important are the following:—

a. The price of carbonisation coals has risen more than the average price of coal, and in particular much more than that of the small coal used for electricity generation.
b. Competitive fuel industries have what might be regarded as monopolies in certain fields which can be used to carry basic costs—oil in the motor fuel field and electricity in lighting. These safe markets enable fuel oil, and electricity for power and heating, to be provided at almost marginal prices.
c. The gas industry is nearing the limit of development of conventional carbonisation processes. These have moreover high capital costs as has the existing extensive but lightly loaded distribution system.

Revealing

The disproportionate increase in the price of gas since the war has been one of the main causes of the lack of progress in sales. This trend is referred to by Dr. Burns in his presidential address to the Institution of Gas Engineers this year[6]. While, as Dr. Burns pointed out, care is needed in making any direct comparison between the growth of different forms of energy, figures for the expansion in sales of these fuels in the post-war years are revealing. Since 1944, the sales of electricity and oil have almost doubled while gas has had to be content with an increase of less than 20%. Sales of coke, the price of which has risen even more steeply than that of gas, are now no greater than they were in 1949.

Smoke abatement. Smoke pollution is in many ways related to fuel wastage and it has been neglected for the same reason, namely, that the value of abatement is much less to the individual than it is to the nation. The cost to the community of atmospheric pollution, that is smoke pollution and acidic pollution, is enormous. The most recent official estimate is probably that of the Beaver Committee[7] which in 1954 put the cost of air pollution at £250 mill. per year '. . . in terms only of losses that can be given a monetary value.' This figure did not include the loss of fuel caused by incomplete combustion, estimated at an additional £25-£50 mill. a year. The measurable losses assessed included increased domestic cleaning, building repairs and cleaning, metal corrosion and additional medical services. The immeasurable losses are probably more important and may be summarised in terms of animal health, vegetable health and fog. The gas industry has a lot to offer towards the abatement of pollution. An obvious example is the improved atmospheric conditions in the potteries as a result of the widespread conversion from coal to gas firing, but a simple calculation can be made for the Tyneside frame furnace mentioned earlier. Assuming this to have been typical of industrial coal burning furnaces, it would have emitted each year something like 17 tons of smoke, 5 tons of ash and 53 tons of sulphur dioxide. Converted to gas, its annual pollution of the atmosphere was reduced to .5 tons of sulphur dioxide. Although a smokeless chimney does not necessarily mean efficient use of fuel, the efficient use of fuel does ensure the absence of smoke. An Act of Parliament to prevent fuel wastage would seem, therefore, to have been a better proposition than one to prevent smoke.

Since our aim should be the abolition of all forms of air pollution and not merely the abatement of smoke, it is interesting to compare the total pollution involved in producing and using equivalent quantities of coal, oil, electricity and gas for an industrial process such as the heat treatment of steel. An estimate is given below of the pollution from such a process requiring 1 mill. therms. The assumed production and application efficiencies are given in Table 3 and the pollution is calculated from figures given in the Beaver report. In the case of electricity, all the pollution occurs at the power station, while with coal and oil it is all at the point of use, no additions having been made for pollution at collieries or oil refineries. The gas figure includes the 10 tons of sulphur dioxide in the products of combustion at the point of use.

TABLE 3
Total atmospheric pollution from the supply of 1 mill. useful therms.

Fuel	Production efficiency	Application efficiency	Total pollution—tons		
			Smoke	Grit and dust	Sulphur dioxide
Coal	100	25	184	69	425
Oil	100	45	small	—	300
Electricity ..	25	75	small	164	545
Gas	50	50	small	small	120

Effect

Production factor. The lack of incentive towards the efficient use of the nation's fuel resources and towards smoke abolition, coupled with the present high price of gas, have had a very marked effect on the sales of gas. The effect would have been disastrous if there were a considerable number of other production considerations, the importance of which is much greater to the individual firm than to the nation. They relate to the output, quality and cost of the manufacturers' product, and play a most important part in the selection of plant and fuel by experienced management. Such considerations are:

a. The capital cost of plant, which has to be allowed for as well as fuel costs. Relative maintenance costs may also be important.
b. Labour. Not only the present high cost of labour, but also the availability of the right type, must be considered. Good working conditions are becoming increasingly imperative.
c. Production per unit of plant. An increased production from the same plant brings obvious benefits in the form of reduced capital charges and other overheads. A case in point is that of a Williamson tunnel kiln for the firing of floor tiles where the

throughput was increased by 85% on conversion from producer to town gas. The rapidity with which plant can be brought into production is of importance and great strides have been made in furnace construction with the introduction of high quality insulating refractories, whose use in batch annealing furnaces, for instance, can reduce the daily heating-up time by as much as one-third.

d. The quality of product. An improvement in product quality may enable a higher specification to be met, a better share of the available market to be won or a higher price to be obtained. A firm which converted a number of Dressler tunnel kilns for the glost firing of wall tiles from producer gas to towns gas gained the advantage of an increase in first grade ware from 70% to 90%.

e. Waste of material can occur, at any stage in manufacture, from loss of raw material to rejects or spoilage in the final product. For instance, in forging at temperatures of the order of 1,300°C., the loss of steel from scaling may be as high as 6% and it had been thought that the atmosphere condition necessary to prevent appreciable scaling was not compatible with the maintenance of furnace temperature. The recently developed Equiverse furnace[8], however, permits completely scale-free heating at these temperatures. Clearly the significance of waste depends upon the material in question, but it also depends upon the manufacturing stage at which the loss occurs and becomes more important as processing costs increase.

f. Finishing or correcting processes. 'Clean' or bright heat treatment may save a finishing process and the absence of distortion in the flame hardening of components certainly saves straightening and machining costs. The latter process, too, often enables a cheaper steel to be employed.

g. Intangibles. There are also many less tangible considerations to which it is more difficult to assign monetary values. Factory space is valuable and the ability of plant to adapt itself to the space available may be of the utmost importance. There is, too, the tendency towards continuous production lines. Plant selected must dovetail in satisfactorily and reliability becomes a major consideration. Good operating conditions, both in respect of cleanliness and temperature, are becoming of increasing importance.

These considerations are the basis upon which industrial gas sales have been built up and their study for a wide variety of processes is the best training for an industrial gas engineer. A knowledge of gas is useful; a knowledge of the customer's process is all important. Gas has not, except in special cases, been sold to industry on price but rather on value, and with today's price, the fullest possible valuation is essential.

At the present time, therefore, it would appear that the gas industry has everything in its favour, except the price of its products and a nebulous but none the less dangerous public opinion that oil is the fuel of the present and nuclear electricity the fuel of the future. Complete gasification, by avoiding the problem of expensive coke and coal transport, will enable very large units to be sited in the coalfields, where coal is cheap. Cheaper grades of coal can be used and possibly the national surplus of small coal which is now tending to increase as nuclear power stations are brought into commission. The use of very large scale high pressure continuous operation will slash capital costs and a high pressure gas grid can become an economic reality.

All this could contribute to a much cheaper therm for the customer and an entirely different outlook for the sales of gas. To quote a recent editorial in 'The Economist'[9], a publication not normally addicted to building castles in the air, '. . . . the chances . . . of a prosperous tomorrow . . . are real and invigorating: As real as, say, economic nuclear power, and eventually capable of providing energy a good deal cheaper.'

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DISCUSSION

Mr. R. F. Hayman, the Gas Council, opening the discussion, said that he agreed that efficiency was a much abused word. Thermal efficiency could be clearly defined scientifically. In many gasworks processes and in straight forward operations such as bulk water heating it was most important, but it must not be considered a dominating factor, since there was often a case in utilisation for the deliberate reduction of thermal efficiency in order to achieve greater production rates or quicker processing.

In Patrick's paper, referred to by Mr. Lloyd-Dodd, high temperature furnaces with a thermal efficiency of 6% were quoted as exemplifying good operating practice. A rise of 1% in this figure would represent a sound technical achievement but would probably be of little use in practice. A furnace at working temperature and at equilibrium, a soaking pit, for instance, had a thermal efficiency of zero.

Close attention to design and thermal efficiency of plant was often nullified by operating carelessness, and the loss of heat from uncovered hot water surfaces might be 60% of the total heat loss from a liquid heating tank.

In spite of the author's brief reference to 'fuel efficiency,' this was most important in industry and was the basis on which a great quantity of fuel was sold. He asked how else did gas compete with oil and producer gas, for it was not on price and it was sometimes not on quality of fuel.

The gas industry was becoming increasingly involved with heating installations. The loss of heat through glass roofs was often heavy, and sometimes could not be avoided. A general appreciation of the cost of daylight was a case where the roof glazing of a factory saved £120 in lighting but added £720 per year to the fabric and heating costs. Without entering into a discussion on the psychological effect of artificial light, closer collaboration with the building industry might enable gas heating to be used in certain advanced designs of building, where in conventional struc-

tures it would normally be too expensive.

Further examples of advances in production quality and improved output using gas were the conversion to town gas from producer gas and solid fuel of three kilns used for firing refractory shapes, in which the output had increased by 20% or 3,500 tons per annum. The combined effects of satisfactory fuel application and increased production had made it unnecessary to build another kiln. In another case, a producer gas fired kiln was modified to direct town gas firing, with the result that output was raised 25%, almost all of which was first or second quality. Previously only five pieces in 40 had been in these categories. Fuel had been reduced by 40% and the manufacturer had saved 2s. 6d. on each piece of ware fired, together with £100,000 on the cost of new plant. Most important of all, the Board has gained a load of 300,000 therms per year, and was now about to convert a second kiln.

There must be, however, a balance between the domestic and the non-domestic loads, but it was worth remembering that the coal equivalent of the industrial load alone was now something like 5 mill. tons. There were over 30 mill. tons of coal still used in industry for a great number of processes, where it was used wastefully for which refined fuels could and would replace it.

Cheaper

Industrial gas was really younger than electricity, and it could be argued on these grounds that it should be more glamorous. If not, he asked, why was it not? Was it because the industry did not spend enough money or enthusiasm on developing sales of gas? The industry had taken great steps forward in new techniques in gas production, with the forward policy of making cheaper fuel available to the consumer.

The most important job now and in the future was to sell all the gas we were going to make in these new plants. Selling was a word which at times sounded a little sordid, but it required considerable skill to sell gas consuming processes to hard headed industrialists.

Mr. J. D. C. Woodall (Tunbridge Wells) said that the paper covered a wide field. It was of the utmost importance that all the facts in favour of gas should be put before industrialists. He agreed with the author that thermal efficiency was of secondary importance, in fact it had reached its optimum value in many plants and the change-over to gas firing would not improve it. National fuel efficiency was quite a different matter and gas could help in this. Fuel conditions had changed lately and more coal than was actually needed was now available. Any national fuel policy would have to ensure the full employment of the miners. The old slogan 'the gas industry makes the best use of the nation's coal' should be changed to 'the gas industry makes the best use of the nation's capital.'

There was no doubt that the burning of solid fuel was going out and the use of refined fuels increasing. This was the gas industry's opportunity and if only the differences in capital cost of gas and electricity could be brought home to those in authority, gas might receive its due recognition. To heat a room of 1,500 cu.ft. 1 therm of gas or 3 kWh. of electricity were needed. The relative capital costs were £30 for gas, £150 for thermally generated electricity, and £450 for nuclear power. This must become apparent to the Government.

He asked what was the point of using electricity for heating when it should be confined to its own job of power production. The use of oil involved much foreign capital and made this country so very dependent on the political whims of the Middle East. He was quite sure that industrialists had not completely recovered from the shock of the Suez crisis. There was even a possibility that any future Labour Government might well put a heavy tax on oil to help the National Coal Board.

The author had referred to the high price of gas, but Mr. Woodall asked whether the industrialist really believed that gas was worth the money. This was a question which the gas salesman must be able to answer in the affirmative.

The South Eastern Board could sell industrial gas at its present price. Gas is far more flexible than oil and has other advantages such as a less destructive effect on furnace refractories. Gas was undoubtedly hard to sell so that great efforts must be made to sell more of it to every category of consumer. In this way it would be possible to subsidise the industrial load to some extent, but in any case the industrial gas engineer was the star of the sales team.

The South Eastern Board were about to start up the new plant at the Isle of Grain. This would mean larger quantities of cheaper almost sulphur-free gas. Two years ago the Board had introduced a most attractive tariff to encourage domestic space heating. It was now showing results and 1,000 gas fires a week were being sold for the replacement of solid fuel grates only. The number of central heating boilers had been trebled in the same period. Mr. Woodall stressed the very real need for sulphur-free gas and said that the engineers must make the most supreme effort to solve this most pressing problem.

Mr. A. E. Tyrrell, N.T.G.B., said that a piece of apparatus which competently caused certain effects might be said to be efficient. Efficiency might be expressed in terms of time, space, human effort, output, in the burning of fuel, or the use of power; it depended upon the duty performed and how closely it resembled the desired result. Since combinations of these features could be found in many pieces of production plant, it was usual to use them as components of ultimate cost which could be directly related to each piece of finished production. By this means a common factor was found for assessing efficiency in any of its forms, and direct comparisons could be made within the factory, or with other and perhaps newer methods of process performance of a similar kind. Changes in any one of these features might very well affect others, sometimes for the better and sometimes not.

Thus efficiency might mean many things and might be expressed in the plant, in the process, or as a component of production costs; it might be seen as a saving in labour, fuel, space or time; whatever the change it must ultimately improve standards, or increase volumes of production or reduce fuel consumption if it was to succeed. As the author had rightly pointed out, confusion between the separate issues of efficiency and cost should be carefully avoided, although at times it might be difficult to separate them. Higher efficiency would almost certainly mean lower costs, and in increasingly competitive markets this was an excellent result, but in cases where fuel costs were a trifling proportion of product cost, it might appear hardly worth consideration. In conditions of high fuel costs no saving was too small.

Overall

The fundamental requirements for high efficiency were good design, correct process performance, and adequate service. Such requirements were common to all processes, whether thermal or mechanical, and it was in the effect created, rather than the cause, that a condition of efficiency was first measured. Overall economies of a process must take into account not fuel and energy consumption alone, but speed, labour, space, reliability and maintenance costs. Good design embraced all the features

that formed total efficiency and preserved a balance between them. Thus plant design was becoming more important but at the same time more complicated.

It was not unreasonable that the industrialist should look to the service providing industries for guidance in design and to know that he could confidently accept their recommendations, but it was becoming increasing frequent in opening negotiations for new business, for the industrial engineer who might know little about economics to be faced with an accountant who might know nothing about engineering. This might be one result of competitive pressure and the tendency to consider costs before all else. If this was so, the industrial gas engineer needed a good background of economics, not only of his own service but those of other industries as well. He needed, too, a knowledge of mechanical as well as thermal engineering for the movement towards integrated production lines with fully automatic control was the ultimate goal for small and large industrial units. This would improve the prospects for the gas industry, provided interest in the problems was taken at the planning stage.

Research and development must go beyond the study of immediate or purely protective problems, so that the gas industry might escape from the situation in which so much time was spent in holding loads it already had and too little in expanding its markets.

The gas industry was becoming competitively depressed through no fault of its own; indeed, this very competition had made it one of the most efficient industries in the country, and however difficult or disagreeable it might be, it was in this background of complete freedom of choice for the buyer that future trading would have to be done. The economist studied the structure of an industry to find out its effect on the functioning of that industry, its response to demand, its adoption and development of new methods and new products, and its activity in developing its markets both at home and abroad.

Such studies revealed the tendency of the industry to change with time or, more probably, its progressive or protective reaction to rapidly changing industrial conditions. We should keep step with the economist in these studies, or we would be in danger of examining the problems too late to capitalise the opportunities they presented. It was expecting too much of the industrial gas engineer to be an economist at the same time, but a study of industrial structures, particularly in the heat using industries, should form part of the work of surveying the markets for extending the uses of industrial gas.

What a paradox it was that, because of the high price of coal, to which the gas industry was so firmly anchored, the more competitively threatened industrialist was often compelled to take an alternative fuel less satisfactory to his needs.

Mr. J. T. Veryard (London) said that the lower costs of production at the Isle of Grain would go a long way towards covering the lower gas prices being offered to the public at the new central heating tariff rates. The new plant would make practically sulphur-free gas with greatly reduced carbon monoxide content. This latter point was most important. It helped to reduce the number of deaths from gassing accidents, since it had been found that the accident death rate bore a straight line relationship with the carbon monoxide content.

Mr. Lloyd-Dodd, replying to the discussion, agreed with Mr. Woodall's idea of changing the emphasis of the publicity theme, since there seemed much to be made from this in getting a bigger share of the market. Gas was certainly worth its present price, but its scope could be considerably widened if it was cheaper. Referring to Mr. Hayman's remarks about the cost of daylight, he said that a case could be made out for cutting it out altogether. He agreed with Mr. Tyrrell that too much effort was made to keep existing loads, but he thought that over the next five or six years, the gas industry might have to preserve what loads it already had until the full development of industrial gas utilisation could be realised with the cheaper gas that would be possible from the new production processes.

'No vices' Emma keeps a date with 200

MR. E. H. HARMAN, Deputy Chairman of the East Midlands Gas Board, speaking at Leicester on October 28, had this to say about the Redfyre Emma boiler: 'She has no vices but many virtues. She is efficient and economical, quiet about the factory, does her work without fuss or bother, needs hardly any attention.

'She is not fussy about her food so long as it's coke, and she consumes practically everything with which she is fed.'

[A description of the boiler was given in July's 'GAS IN INDUSTRY.'

The occasion was a demonstration of the first Redfyre Emma to be installed in this country at the Belgrave Gate premises of the East Midlands Gas Board, Leicester. Mr. Harman's remarks were made at the luncheon at which the hosts were the East Midlands Gas Board and the makers of Emma, Newton Chambers & Co., Ltd.

Some 200 guests, including heating engineers, architects, municipal officials, industrialists, representatives of Government departments and of the various gas boards, attended the demonstration.

At the Leicester demonstration (left to right): Mr. P. J. C. Bovill (Managing Director of Newton Chambers Co., Ltd.), Mr. G. le B. Diamond (Chairman of the W.M.G.B.), and Mr. R. S. Johnson (Chairman of the E.M.G.B.).

Mr. P. J. C. Bovill, Managing Director of Newton Chambers, welcomed the guests.

Midlands firm installs new gas-fired heat-treatment shop

AN old-established firm in the steel industry, which has for many years been a large consumer of town gas, has recently put down an entirely new heat-treatment shop with many labour-saving features.

This is the firm of A. E. Godrich & Son, Ltd., of Wharf Street, Birmingham, who are well-known bright-drawn-steel manufacturers supplying a wide range of steel products ranging from bright-drawn material to steels required in a bright-drawn condition, as well as considerable quantities of wire which has to be subsequently cold-headed into rivets, bolts, nuts, &c.

The qualities include mild steels, medium carbon, alloy, and free-cutting steels. The sizes are up to about 2½ in. diameter, the maximum size depending on the quality. A considerable proportion of the output is used by the motor industry, either direct or through component makers, the remainder going to the general engineering industry.

This year, the Godrich organisation have replaced four older manually operated natural-draught furnaces by a modern installation pictured on these pages which embodies the latest practice in furnace control and mechanical-handling equipment.

The instrument cabinet.

The installation consists of three furnaces with internal dimensions 4 ft. wide by 20 ft. back to front by 2 ft. 3 in. to spring of arch, for working temperatures of between 500° and 950°C. Firing is by natural-draught burners, each furnace being equipped with 42 burners, and each furnace having a maximum gas rate when heating up from cold of slightly over 5,000 cu.ft. per hour, which will show the importance to the Gas Board of an installation of this type.

The consumption is, of course, considerably reduced for continuous working. The design includes air recuperation, special insulation, pneumatically-operated rise-and-fall counterbalanced doors at the charging end, and frontal gas curtain. The gas burners are of the atmospheric-injector type with dual calibrated jets, arranged so that there is always a measurable pressure available for regulation even at the smallest turn-down.

An outstanding feature of the installation is the automatic centralised temperature and pressure control from the cabinet at the right-hand side of the third furnace. The method of control can be followed from Fig. 1, which enables close limits of temperature to be maintained in the load.

Each furnace has two zones, both being independently controlled by an Ether 'Transitrol' indicating temperature controller (C) operating Satchwell motorised valves in the main gas supply. Duplex thermocouples (A) are used, providing a recording of all operations on a series 800 two-point recorder (B), the charts of which furnish a record of a month's complete day and night work. When in operation, the motorised gas valves (D) operate solenoid air valves (E) which

General view of the new heat-treatment shop (compare with Fig 2).

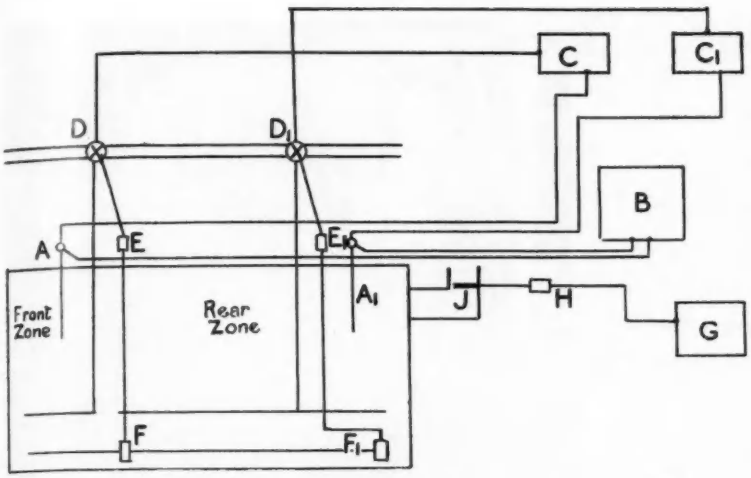


Fig. 1. Control system: A, thermo-couples; B, recorder; C, controllers; D, motorised gas valves; E, solenoid air valves; F, cylinders for secondary air control; G, furnace pressure controller; H, proportional valve; J, Slide.

automatically control the position of the secondary air slides (F) ensuring a constant CO_2 atmospheric content. Furnace pressure is controlled by a Bristol's low-range draught and pressure controller (G) also housed in the same cabinet, actuation of the furnace damper for this purpose being effected by a syncro-lever motor.

The quenching machine is located in line with the furnaces as shown by the layout drawing of the shop, Fig. 2, having a pneumatically-operated rise-and-fall gear, and capable of high speed of operation, a point of capital importance when dealing with certain classes of steel such as EN 8. Incorporated in the quenching machine is an impeller directly coupled to a 5 h.p. motor (720 r.p.m.) to ensure adequate agitation of the quenching medium which in addition is also circulated through a cooling system.

The charging machine

Another striking feature of this new installation is the electro-pneumatically operated charging machine. The importance of this will be appreciated by all who have been accustomed only to hand-operated plants, for in this connection the difficulty of obtaining suitable labour has always to be borne in mind, as work on manually-operated plants is generally carried out under exacting and trying conditions.

As a general rule in the furnace trade it is reckoned that each furnace operator nowadays costs £500 to £600 per annum, apart from overheads. Thanks to the convenience and ease of manipulation of the charging machine installed here, one man can take over the whole handling of the work from the loading tables, through the various sequences, finishing finally at the unloading tables, without having to leave the platform of the machine.

The operations can be better followed by reference to the layout diagram, Fig. 2, from which it will be seen that this platform is at the side of the machine, and from this position the attendant can run the machine along the rails to any point across the shop, automatically stopping at the exact position necessary to load or unload a furnace, table, or quenching machine without the necessity for any final adjustments or inching, this exact positioning being obtained by a special locating device in connection with locating holes. From the same position, the operator also controls the opening and shutting of each furnace door and the rise-and-fall mechanism of the quenching bath.

Due to exigencies of space available for the building which houses the plant, it was necessary to lay out the installation extremely carefully to ensure that the whole area was used to the best advantage, so as to give an efficient and economic flow of work throughout. Thus the furnaces will take not only bars, but wire rods in coils, or wire in coils weighing up to 500 lb. each, as well as forgings and castings.

Method of loading

The operation of the charging machine in loading (for instance) No. 1 furnace would be to run the machine to the left until the travel is automatically stopped by the appropriate locating device (L) having previously rotated the arms to point to No. 1 table, advance the arms of the charger under the load of material resting (in the case of steel bar) on frames on this table.

The arms of the charging machine are then raised so as to lift the load off the table, the arms retracted, and the machine run to the middle of the shop where the arms can be rotated through 180° to face the line of furnaces. After this the machine is moved back until it is in the correct position for the load to be put into the furnace, where it is arrested automatically.

Still without leaving the platform the operator by means of an overhead pendant-switch raises the furnace door, and charges the load into the furnace. The arms are then lowered

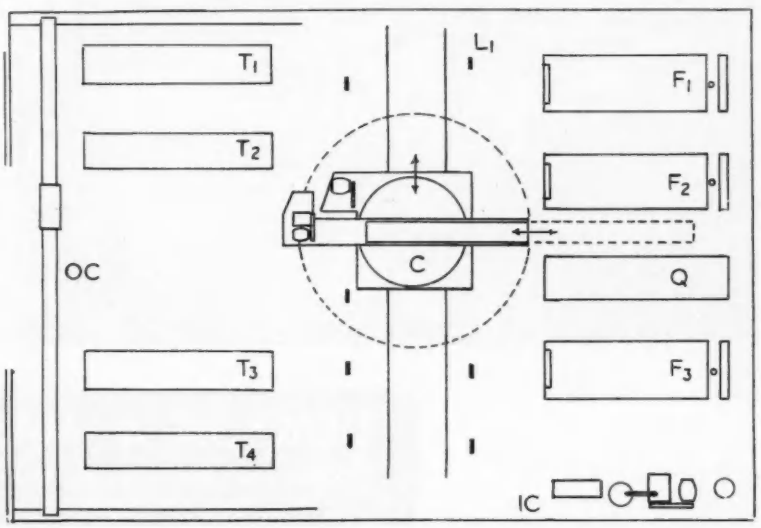
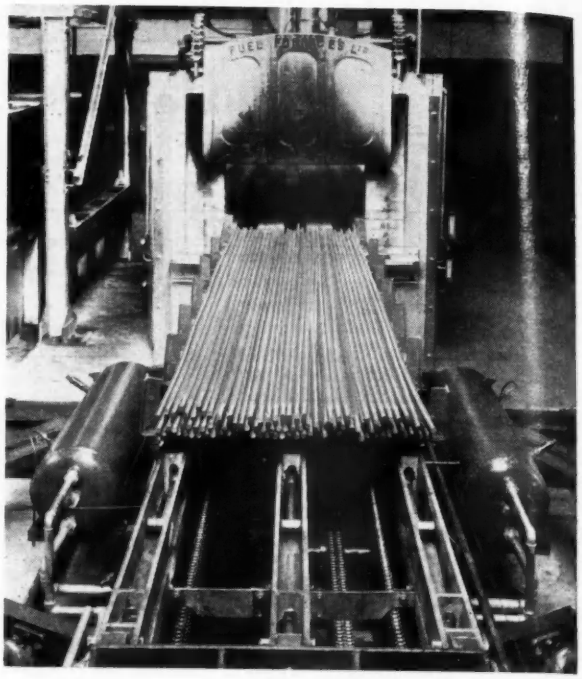


Fig. 2. Layout of heat-treatment shop: F, furnaces; Q, quenching machine; C, charging machine; L, location holes; T, work tables; OC, overhead crane; IC, instrument cabinet.

so that the charge now rests on the hearth, the arms are retracted and finally by means of the overhead pendant-switch the operator closes the furnace door again. The charging machine and each of the furnaces have a nominal capacity of four tons, and the whole charging operation as just described can be carried out in four minutes.

The installation described has a capacity of some 500 to 750 tons per month, the actual figures depending on the proportion of hardening and tempering, normalising, and annealing carried out.

Equipment installed the new heat-treatment shop includes furnaces, quenching machine, and charger by Fuel Furnaces, Ltd., Gt. Barr, Birmingham; temperature control equipment by Ether, Ltd., Tyburn Road, Birmingham; pressure control equipment, Bristol Instrument Co., Ltd., Century Works, London, S.E.13; air compressor, Broom & Wade, Ltd., High Wycombe.



Close-up view of charging machine in operation at No. 3 furnace.

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The economic use of gas in industry

by
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COMPLEXITY of modern operations and processes necessitates the increasing use of refined fuels. These fuels can be expensive to use unless plant is designed for the process which it is intended to serve. Gas is a refined fuel, and the economics of its use are closely bound up with the importance of design of equipment for specific operations.

Some 85% of the energy resources of the country are based on coal. In spite of great progress in the use of oil in industry, forward plans for the production of electricity by nuclear energy, and a steady growth of the use of gas in industry, coal will predominate as a fuel for many years to come.

This country has had cheap coal for generations, and has wasted it—our chief natural raw material—prodigiously. It is when the price of fuel begins to rise that more thought is given to methods of using it.

Economic climate

Often the first reaction is to economise on fuel rather than insist on improved design. This can result in inferior service, a condition of which the British race is sometimes peculiarly tolerant.

This paper deals with the economic application of gas in industry, bearing in mind the economic climate in which the gas industry now lives. Gas is a manufactured fuel, readily available, easy to use and equally easy to waste.

It is necessary to examine its use, its value and its future in that light. Long-term plans for the manufacture of a cheaper therm are active, and much publicity has been given to the 'new look' of the gas industry. The prospects, invigorating as they are, will not be discussed in this survey, concerned as it is with existing sources and prices.

Table 1 shows the rate of growth of sales to industry over the last few years.

Table 2 shows the approximate amounts of gas sold to industry in 1957-58 by the area boards.

The total figure of approximately 786 mill. therms is 29% of the load. This figure, representing conditions approximately prevailing at the end of the 1957-58 year (March, 1958), is 5% greater than that of the previous year, and is still rising.

The steady growth in the industrial gas load is in part due to the straightforward advantages of gas as a fuel. Gas is clean and easily controlled, and can be made available in any quantity at any pressure required. Equipment is available which, while burning hundreds of thousands of cubic feet an hour at high pressures, can be turned down immediately to burn a fraction of a cubic foot of gas with complete stability.

The immense flexibility and turn-down ratio of such burners enables them to be incorporated in combustion chambers of all kinds. All these attributes, however—some of them certainly not peculiar to gas—are not in themselves sufficient to turn the economic scale in competition with available alternative fuels often costing half or a third of the price per therm.

Why buy gas ?

The advantages of gas in terms of ease and availability, flexibility of control and use have been assessed as being worth 3d. to 4d. per therm. There is still a large price differential compared with some fuels, and the question can be asked, why is any gas sold to industry at all?

Improved quality of production and increased production rates are not mere 'talking points' or headlines for paragraphs. They are the foundations of prosperity and ensure repeat orders to many firms.

To achieve a reputation for rapid and high-quality production, other points must be taken into account. The use of the right fuel may achieve valuable results in lower maintenance costs, longer life of refractories and insulating refractories, lower heat losses from exposed surfaces, lower flue losses, less excess air, less labour for operation, for cleaning up, or for fuel handling.

All these factors should be assessed fairly, and set off against the increased price per therm of a fuel to which a change is contemplated.

Various meanings

Mr. E. A. K. Patrick (Efficiency of Industrial Gas Appliances. Inst. Gas Eng. Comm., No. 527, 1958) has discussed the various meanings that may be attached to the word 'efficiency' when it is used to describe the performance of fuel-using equipment.

To the industrialist, an important conception of efficiency is 'production efficiency.' In many processes the plant which will in the end be chosen and used is the one giving the least overall production cost, and in this connection there is a wealth of meaning in the word 'overall.'

There are many instances where an improvement in quality of production justifies the use either of more fuel or of a more refined fuel. The significance of waste increases as work passes through a factory, and the investment of heavy labour costs in the fabrication of an intricate component

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The above article was read as a paper to a technical meeting of the 1958 Industrial Fuel Efficiency Exhibition at Olympia, London, as one of a series on 'Lower costs and higher production through better fuel utilisation.'

TABLE 1.—GAS SOLD TO INDUSTRY

	1950–51	1951–52	1952–53	1953–54	1954–55	1955–56	1956–57	1957–58
Millions of therms.. ..	590	624	639	659	720	751	750	786
% of total load	24·0	25·2	25·3	26·2	27·3	28·4	28·7	29·0

TABLE 2.—GAS SOLD TO INDUSTRY, 1957–58 (APPROXIMATE)

	Sc.	N.	N.W.	N.E.	E.M.	W.M.	W.	E.	N.T.	S.E.	S.	S.W.
Millions of therms	46	59	115	41	148	167	28	34	79	40	13	16
% of total load	23	34	32	28	49	51	31	23	19	14	11	14

must not be thrown away by the wrong application of fuel for the final heat treatment, often a vital part of the finishing operation.

Mr. Patrick gives details of a large broach which contains special steel worth approximately £135; some 35 man-hours have been spent in working upon it up to the stage where it receives heat treatment. It can be spoiled during heat treatment which involves a consumption of gas worth approximately 6s.

It is safe to say that almost any quantity of extra fuel would willingly be burned in an effort to save one such broach, once the labour and skill devoted to its manufacture have been invested in it.

Industrial requirements clearly indicate that what matters is the cost of fuel per unit of production. The amount of fuel used in many processes is, or can be—particularly to the production engineer—of importance secondary to that of how it is used. It is for reasons of this kind, associated with quality of production and elimination of rejects, that refined fuels fulfil essential demands.

Some factors cannot be assessed with accuracy until operating experience has been gained. Plants converted or redesigned to burn gas recover the cost in many ways, not the least important being saving of labour and maintenance costs. The following examples show results of such work.

Neglected

Enough effort is often not put into designing equipment having the minimum unnecessary heat losses. The use of insulating refractory materials —again far from specific to the gas industry—is still neglected, and there are many applications where a careful study of the advantages of insulating materials of low heat capacity can save a lot in running costs.

A typical instance is that of a gas-fired furnace originally lined with firebrick, but now lined with insulating refractories. Fuel consumption, after relining, dropped by some 30 therms a week. equal to a saving of 15% or, expressed in other terms, 15s. a ton of steel heated.

Insulating refractories have other advantages in that by their use the furnace can be heated more rapidly from cold, and it is possible to achieve a better temperature distribution.

These advantages are not peculiar to gas, and the instance mentioned does not represent a unique achievement, but such an approach to design is essential if refined fuels are to be used economically. In fact, it can be said that such developments make this use possible.

The use of a refined fuel demands high standards of design, if only because unnecessary waste means expensive fuels being lost to the process. An example is seen in the melting of aluminium for die-casting, where the use of liquid fuel demanded, for a given temperature, a consumption of 2.5 therms an hour.

Reduced consumption

Redesign, employing gas heating, reduced the overall requirements for the same holding temperature to 1 therm an hour, substantially because of the elimination of unnecessary excess air.

There are many instances, as here, where melting of metal by other fuels is cheaper, but the holding of metal to an agreed condition is best done by gas because it is possible to control temperatures and heat losses more easily at lower rates. Selection of the right fuel for the right process demands experience and knowledge, and the gas industry is always available for consultation wherever there is any doubt.

Most of the following are examples of improvements as a result of consultation by the consumer with the area gas boards.

Conversions are, in general, less desirable than new installations. To achieve the best results for a given process, the heat service should be designed from the beginning. This is not always possible, but the policy in conversion of existing plants must relate to the finished product.

Will the new plant save money, and if so, how? Even if the thermal cost of output a ton is higher, will the overall cost of production per unit of output be lower? Examples of effective conversions are given below.

Six double-deck ovens have been converted from solid-fuel fired automatic stokers to gas firing. Consumption of coal a sack of flour is 51 lb.; consumption of gas a sack of flour is 3.1 therms. With an annual quantity based on approximately 26,000 sacks of flour baked, this represented a saving of 60 tons of coal (10%) a year.

Over the last few years there has been a major conversion from producer gas to town gas in a ceramic works. Modification of two 200 ft. kilns has enabled the throughput to be increased by 25%, and the yield of first-quality ware to be increased from 70 to 90%, with similar results for other kilns. Gas consumption in these works increased from 28,000 to 876,000 therms per annum, and is still growing.

Conversion to town gas from producer gas and solid fuel of three kilns used for firing refractory shapes has increased output by 20%, or 3,500 tons per annum. The combined effects of satisfactory fuel application and increased production have made it unnecessary to build another kiln.

It is always desirable to use direct-fired gas equipment where practicable if for no other reason than that the thermal efficiency of utilisation is high. In many processes, hot, clean products of combustion can replace indirectly heated hot air with considerable saving in size of plant, in capital and running costs, and in heating-up rates.

Control of directly heated plant can be made more positive and precise; this leads to closer control of heating cycles, and in turn to ware of better quality and elimination of rejects.

Two solid-fuel fired sand-drying units have been converted to gas by the installation of four post-aerated burners. The drying of sand lends itself admirably to direct gas firing. The conversion resulted in trebling output, labour now being required only to replenish the hopper.

Changed to town gas

The advantages of consulting area gas boards in the early stages of process problems are shown by an instance where a manufacturer of sanitary ware was persuaded to have a producer-gas fired kiln modified to a design produced by the Board, and converted to direct town-gas firing.

As a result, output was raised 25% and almost all of it was of first or second quality. Previously, only five pieces in 40 were in these categories, and many were rejected. The fuel used was reduced by 40% and the

manufacturer is saving 2s. 6d. on each piece of ware fired, and upwards of £100,000 which he had proposed to spend on new plant. The Board has gained a load of 300,000 therms per annum, and has received instructions for the conversion of a second kiln.

A large muffle-type kiln, fired with producer gas and originally converted to indirect town-gas firing, has now been successfully converted to direct or open firing. The average gas consumption over a fixed period was reduced from 23 to 14 therms an hour, thus eliminating complaints of high running cost.

A higher standard of finished product resulted from better control of atmosphere conditions, and this allowed also the use of many other glazes and colours which had not previously been satisfactory. Increased throughput was obtained because of improved heat distribution throughout the kiln.

Important date

The following are examples of replacement of other fuels by gas. January 1, 1956, was an important date in any foundry; on it the 1953 Iron and Steel Foundries Regulations (Statutory Instruments No. 1464, 1953) became operative.

These Regulations demand that 'adequate measures are taken to prevent, as far as practicable, fumes or other impurities entering into or remaining in the atmosphere of the workroom.' Gas has been a substantial factor in ensuring that these demands are met.

Two problems of interest on the foundry floor are those of drying out a ladle which has been re-bricked to make it ready for use, and of pre-heating a ladle to an agreed temperature before it is ready to take molten steel. Experience shows that the use of gas instead of solid fuel has reduced the drying times of relined ladles by 60%, a corresponding number of ladles becoming available for use.

The added advantage of flexible connections has meant that drying can be undertaken if required at almost any point within the foundry, thus avoiding the need to transport the ladles to a central point.

Other provisions of the Foundries Regulations concerned with the clean heating of foundries, and with the supply of hot water for washing and other facilities, have been met by the installation of equipment.

The following is an example of the use of town gas in a process where, although fuel costs were higher, it has been shown that—apart from the general advantages of gas—overall costs are lower than those of producer gas. The displacement of producer gas was in a large aluminium foundry, where it was used exclusively for the heating of a large number of heavy dies.

The plant had difficulty in meeting fluctuations in demand, and at times producer gas was blown to waste. The figures on the basis of a gas/coal equivalent of 150 therms a ton are:—

Consumption of anthracite in producers, per annum—850 tons.
Town gas consumption after conversion, per annum—92,000 therms ≡ 612 tons coal.
Coal saved annually—238 tons (28%).

Increased production is one way of making the most of a refined fuel. Equally important is the saving of unnecessary heating or preparation time, thereby reducing overheads and increasing production rates.

A set of four air-blast burners with a maximum rate of 20 therms an hour has been supplied for pre-heating a glass-melting tank after re-bricking. The burners were removable after use. It is believed that this is the first time such a method of heating has been applied in this country.

There has been a saving of three days in the pre-heating period, and the consumer considered that, with the greater ease of control and the even heating of the brickwork, the life of the setting should be extended from three to four years.

Pre-mix or air-blast burners have been developed from which hot gases are ejected at high velocity through a narrow slot, with a heat release of the order of 250 mill. B.t.u. per cu.ft. of combustion space. These burners are being applied in rapid heating, particularly where local heating of thick metal parts is required.

An example of this technique is in pre-heating the seating of valve bodies before metal deposition; the required portion of a two-ton valve is heated to 750°C. in 12 minutes, a process which previously took six hours.

Largest single load

Gas used for firing ceramic materials provides the largest single load in the country; most of it is concentrated in the area of the West Midlands Board. The Board has developed a multi-passage kiln which combines the efficient operation of the continuous kiln with the convenience of the intermittent kiln; that is, it may be shut down for, say, the week-end, and quickly brought back to temperature and put to work, a feature particularly valuable where trade is variable.

The first production plants are now being put to work. The measure of their success is illustrated by one installation which replaces a coal-fired bottle kiln for the firing of glazed tiles; here, apart from the many attendant advantages of the new system and fuel, coal costing £12 has been replaced by gas costing 35s.

A small rectangular-section nimonic muffle furnace has been designed and constructed for the continuous heat treatment of nimonic turbine blades. It employs a hydrogen atmosphere. The new technique should give a saving of 60% in heat treatment costs.

Previous practice was to use a large oven furnace of conventional design with containers into which the turbine blades were inserted. The containers were then welded. A hydrogen atmosphere was fed in through small-bore heavy-section tubes attached to the containers.

This method of production was expensive; the ends of the boxes had to be cut off after each heat treatment cycle to remove the turbine blades, so that after about five cycles the container was too short for further use.

The new furnace is designed for continuous operation; it is expected that the saving, by elimination of container replacement and reduced gas consumption, will approach £60 a week.

Continuous service

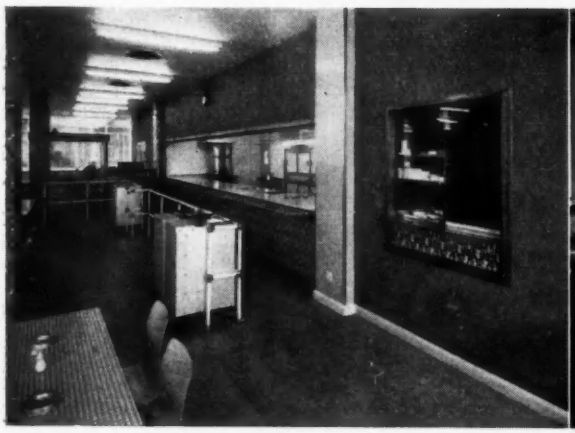
Fuel economy is achieved not only by the supply of suitable equipment. The gas industry believes that the consumer needs a continuous service to ensure that available energy is being used to best effect, and to keep him informed about equipment designs.

The area boards maintain industrial gas departments, staffed by qualified industrial gas engineers who can always be consulted. It is important that they should be consulted by both consumer and manufacturer when an installation is being planned, so that adequate gas supplies can be available, a satisfactory layout of plant and controls achieved and technical advice given if needed. The continuous aim is to increase the use of gas in industry, and to see that every consumer receives maximum benefit from his supply.

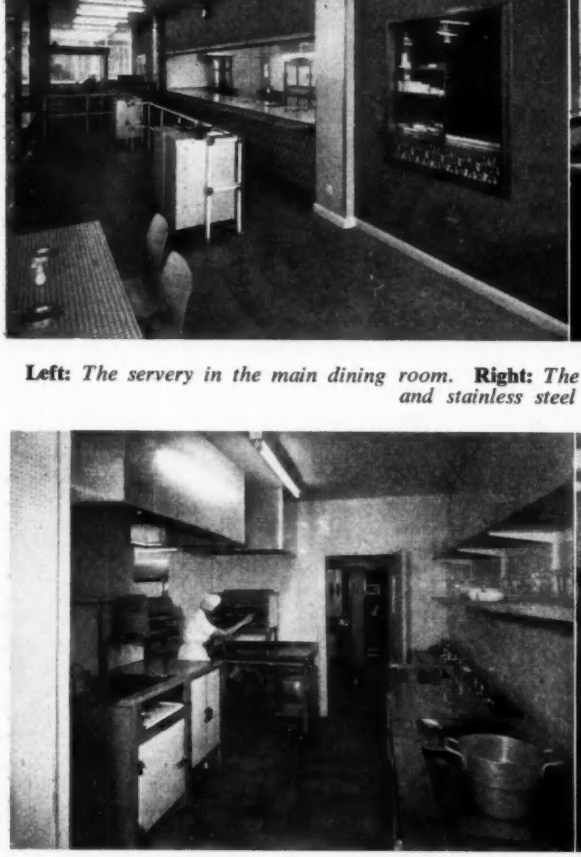
The Clean Air Act and the Foundries Regulations have between them set new standards for factory working conditions. It will now be obligatory in many instances to instal equipment which does not produce dark smoke or noxious fumes.

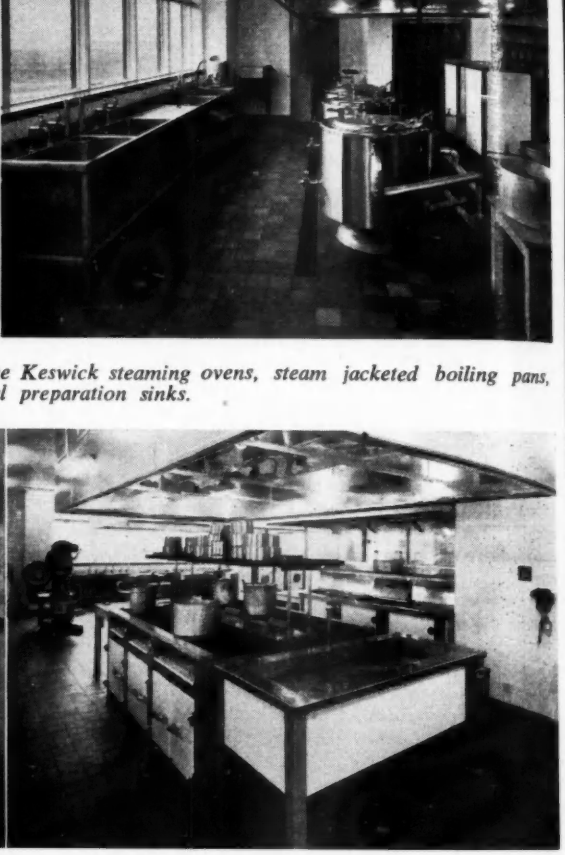
The gas industry is helping to fulfil these requirements, and it can be argued that every piece of gas equipment installed is a contribution towards clean air and saving of coal. With the great predominance of solid fuel as an energy producer, there is enormous scope for gas as an increasing source of heat energy for industry.

Chemical company erects welfare block



Left: *The servery in the main dining room.* **Right:** *The Keswick steaming ovens, steam jacketed boiling pans, and stainless steel preparation sinks.*





Left: *The Stratford combination range and Savoy griller adjacent to the directors' dining room.* **Right:** *General view of the kitchen, showing six-unit Stratford range, bain marie, and three-unit Kingfisher fryer.*

A LARGE portion of the new welfare block erected for the Ashburton Chemical Co. Ltd., Trafford Park, Manchester, is devoted to kitchens and dining rooms for management, staff and workpeople.

Radiation Group Sales Ltd., Large Apparatus Division, were the kitchen engineers and they were responsible, through the architects, Scherrer & Hicks, for the layout of this section. The kitchen equipment comprises a six-unit central Stratford range, three-unit Kingfisher fryer, stockpot stands, Keswick steaming ovens, steam jacketed stainless steel boiling pans and Savoy griller. A separate kitchen accommodates a Stratford combination range which is used mainly for the preparation of meals for the directors' dining room.

Dining rooms occupy two floors of the block with cafeteria service to each and also waitress service to the restaurant. The counters comprise hot and cold sections, the former with adequate bain marie accommodation to ensure the serving of really hot meals. Two-tier hot closets behind the counter accommodate plated meals for those requiring them. The front of the counters are attractively finished; the kitchen is fitted with ample stainless steel preparation tables and sinks, and with labour saving machinery such as dishwashing, mixing, peeling and chipping machines.

ANNEALING EXTRUDED ALUMINIUM TUBES

THE installation of conveyor type furnaces has resulted in increased production of aluminium tubes in the Feltham, Middlesex, factory of Impact Extrusions, Ltd. These tubes are required in hundreds of thousands in various sizes for the packaging of toilet preparations and cosmetics, such as toothpaste and hair cream. They are particularly useful for the marketing and economical use of the more expensive creams.

In the extruded state the tubes would be too hard for satisfactory use and they are therefore annealed at a temperature of 500°C. in conveyor-type furnaces, utilising high temperature radiant surfaces combined with high velocity air circulation, ensuring rapid heating of the articles passing through the furnaces on a wire mesh conveyor line.

The furnaces were designed, constructed and installed by the North Thames Gas Board.

AUTOMATIC CONTROL OF TOWN GAS CHARACTERISTICS

By K. A. STEELE, George Kent Ltd.

A.M.I.Mech.E.

CONSIDERABLE attention has been paid in the industry recently to new methods of gas manufacture, and in order to take full advantage of these, it is becoming a practice to concentrate manufacture at a few large stations in place of many smaller ones. In turn this has led to the setting up of grid schemes so that in order to meet load demands, the gas supplied to any point may be a mixture of component gases supplied from several sources. The gas has a constant calorific value to fulfil statutory requirements, but the characteristics may vary quite considerably due to changes in gas density. The effect on the properties of the flame produced may not be enough to interfere with the majority of consumers, but it will seriously upset the operation of sensitive plant where the flame must be completely stable. For these applications a method of burner resetting may not be a satisfactory answer especially since, on a grid scheme, the type of gas present at a particular take-off point may change rapidly due to movement of the boundary between gas from one source and another. It is not difficult in such cases to imagine a state of affairs where gas supply alternates between one side of the boundary and the other, thus making manual correction an impossibility. Fig. 1 shows the characteristic of gas supplied in the London area over a short period recently. It will be observed that the calorific value remains constant but due to density changes, the burning property of the gas expressed by the Wobbe Index is subject to quite considerable fluctuation. A method of overcoming the effect of rapid changes might be to install a capacity between the take-off point and the user's equipment, but practical consideration will rule this out as a solution for the majority of applications. Nor must is be taken that this is a problem peculiar to isolated instances in narrow fields of manufacture, but obviously as the gas grid expands, a larger number of plants sensitive to gas characteristic will be affected. Possibly the effect will not be serious for the majority of installations, but certainly there will be variation in gas supplied to meet summer and winter demands. Although in the past there has been close liaison between the gas manufacturing station and the consumer, it must be admitted that this is not a completely satisfactory method of dealing with the problem for the type of plant described above.

On a plant with a high rate of throughput the amount of work scrapped during abnormal conditions may represent a large sum of money; as a result it is unsound practice to wait until faults develop before attempting to discover the cause and apply corrective measures. By the time the final stages of manufacture are reached, the work has probably passed through many stages and faults could be attributed to one of several sources. There would then follow a period of investigation, during which faulty work may still be produced. Even if we assume that the prime cause lies in the characteristic of the gas, the nature of the variation will in all probability be periodic and this alone will not assist the investigation. A logical approach, therefore, leads to the desirability of eliminating variables, and furthermore to do this at the earliest stage possible. There are obvious advantages in the application of automatic controls to a problem such as this.

From a paper to the Eastern Junior Gas Association, Letchworth, October 9

a. Automatic control is continuous and consequently does not suffer from fatigue or intermittent disturbances as in the case of manual observation and regulation.

b. Using modern methods of control the disturbance to plant will be the absolute minimum consistent with maintaining a controlled condition.

c. Within the range of the controller, load changes are compensated automatically, although additional equipment may be necessary if these take place suddenly.

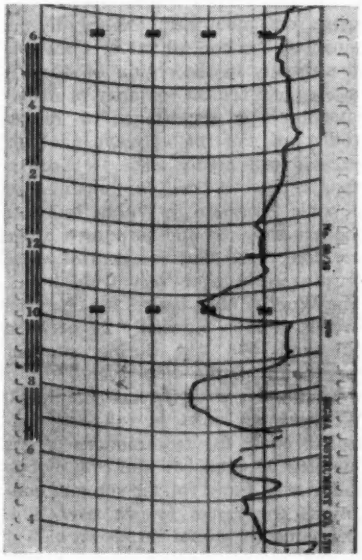


Fig. 1.

Before any attempt can be made to apply automatic control, it is necessary to establish a standard to relate the heating properties of the gas and the geometry of the flame produced. Continuous measurement must then be introduced to obtain a comparison of the gas supplied to the plant with the standard. Reference can be made here to the aeration test burner which has long been used as the standard for assessing the performance of a gas flame. Since the A.T.B. number is an indication of the air requirements to produce a flame of prescribed pattern, it follows that the standard should be based upon the physical properties of the gas/air mixture. Let us consider the simple burner.

Heat release in unit time = Q × CV.

Where Q = quantity of air/gas mixture.
CV = calorific value.
h = pressure loss in system.
P = pressure available.
d = specific gravity of mixture (air = 1)
T = temperature.

$$\text{But } Q = K\frac{hP}{dT}$$

If the pressure in the system is closely governed, Q and the pressure drop may both be regarded as constant. The temperature also may be assumed constant.

$$\text{Thus } Q = K_1\sqrt{\frac{1}{d}}$$

But heat release =

$$Q \times CV = K_1\sqrt{\frac{1}{d}} \times CV.$$

Therefore the heat release for a

given burner operating under closely controlled conditions varies as $\frac{CV}{\sqrt{d}}$ which by definition is the Wobbe Index. It should be noted in passing that since the specific gravity of the gas is relative to that of air, the units of Wobbe Index are the same as those for cv, *i.e.*, B.t.u. per cu.ft. or kcal per cu. m.

Constant Wobbe Index

An automatic control system would include the measuring unit and meter, the controlling unit, the regulating unit (control valve) and the plant, as illustrated diagrammatically in Fig. 2. The measuring unit is the differential linkage in the burner tube assembly of the sigma Wobbe Index recorder; the controlling unit is the Kent Mark XX mechanism inside the controller; the regulating unit is the valve controlling the quantity of air introduced to maintain a constant Wobbe Index, and the plant itself in this case consists of the burner assembly. The burner assembly acts as a pilot plant and the main supply of gas to the process is actually controlled as an open loop, that is to say the process itself is not part of a closed loop control system but is controlled by adjustment of the gas supply. The controller itself employs 3-term control action and it is not within the scope of this paper to cover the full implications of this[1]. Three-term control action may, however, briefly be summarised as a combination of proportional, integral and first derivative actions.

Proportional control. In this action the movement of the control valve is in direct proportion to the deviation from the control point.

Integral control. In the integral element of the control, account is taken of the period for which the measured value differs from the controlled value. As this deviation is sustained, the control action increases and it therefore follows that the element introduced is the time integral of the deviation.

First derivative control takes account of the rate of change between control setting and the measured variable.

These three terms can each be adjusted independently so that in combination a practically straight control line is obtained.

There are several methods of controlling Wobbe Index and the choice must depend upon individual considerations. Details are given of four methods and these have been applied quite successfully in practice.

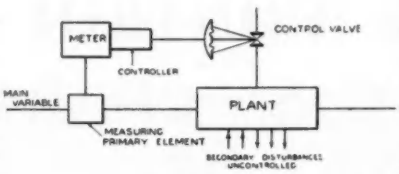


Fig. 2.

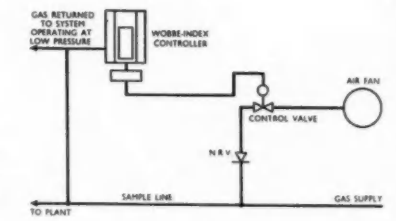


Fig. 3.

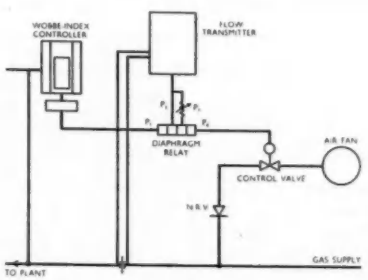


Fig. 4.

1. Direct introduction. Fig. 3 shows a simplified arrangement of this system. Gas is fed in to the plant and dilution air from a separate blower is introduced. A sample of this mixed gas is taken and the Wobbe Index maintained to a constant value by operation of a diaphragm control valve in order that the gas is of constant flame characteristics. The main advantage of this system is that the range of control is limited only by the range of the control valve; since this is normally in the region of 40:1 it is adequate for the majority of installations. The importance of rangeability of control valves cannot be stressed too highly since it becomes apparent when the combination of possible variations in Wobbe Index of the gas supplied and turndown range are considered that the control valve must operate over very wide limits. The Wobbe Index figures for one area in this country normally lie between 666 and 698 but during summer months this figure may reach 730. If we assume the control is set at 660 Wobbe Index units the range of control to cover the requirements of gas supplied between 666 and 698 Wobbe Index is 5:1 and for the summer conditions the range is just over 8:1. Consequently a load turndown of 8:1 is just practicable for normal conditions but this is reduced to about 5:1 during the summer months. In the above, no allowance is made for the fact that control valves are usually supplied with ports to standard dimensions. When this is taken into account the above ranges are of course decreased. It is therefore most important that control valves should be sized correctly and if there is a possibility of large turndown in addition to wide variations in Wobbe Index it is desirable to use two control valves with some form of selection between them. An alarm system could conveniently be incorporated to warn the operator when valves are approaching their saturation point. It will also be appreciated that with this system of direct introduction there is an unavoidable time lag between a change in gas characteristic and a correction applied to the air or other modifying agent. This lag, which can usually be kept down to a period in the order of a minute, is not sufficient to impair operation of the instrument in correcting for density changes brought about by change in composition. It may however prove objectionable when rapid fluctuations in load occur and for this reason this particular method of control is not suitable for installations of this type. In such cases the second method is more suitable.

Modifies Signal

2. Direct injection with anticipatory signal. This system is illustrated in Fig. 4 and the same equipment is employed except that a flow transmitter and diaphragm unit are now added. The function of the relay unit can be expressed in the form PO = P1 + P2 − P3, where P1 is the control signal from the Wobbe Index controller, P2 the control signal from the flow transmitter, P3 the temporarily corrected form of the signal from the flow transmitter and PO is the signal to the control valve. In operation as soon as a flow change takes place the output of the flow transmitter P2 modifies the signal from the Wobbe controller and consequently causes an alteration to the output signal PO. Immediately following this, and in continuous movement, signal P3 then begins to nullify the effect of signal P2 but does so at a reduced rate commensurate with the rate of response of the Wobbe Index controller. As a result under steady conditions PO = P1 and PO is only modified when a flow change takes place. In practice therefore the flow transmitter anticipates a change in Wobbe Index and corrects the air flow rate; this correction signal dies away but as it does so the Wobbe Index controller resumes full control and stability is again obtained. It will

be appreciated that this system overcomes the defects due to time lag in the Wobbe instrument.

3. By modifying the air gas ratio system. The Selas mixing machine is widely used for the control of air gas ratio on various installations in this country and is taken as an example of a scheme for Wobbe Index trimming. Gas is supplied through a governor which reduces the pressure to atmospheric; it then passes to a proportioning valve which also mixes the streams of air and gas. Correct flow ratios between air and gas are maintained since the air is also introduced at atmospheric pressure; the mixture is passed through to a positive type rotary compressor and delivered to the plant. The proportioning valve can be altered in order to obtain different mixtures and in addition the air and gas ports may be opened or closed together in order that the throughput of the machine may vary with the plant demand. By this means the volume of mixture is regulated in relation to the varying loads while the air and gas ratios are maintained. In order to compensate for Wobbe Index changes a sample is taken at the outlet of the compressor and the output from the controller operates a power cylinder connected to some form of linkage capable of varying the proportioning valve adjusting device. Thus the ratio of air and gas is trimmed continuously to maintain a stable Wobbe Index and at the same time an anticipatory control action is achieved by the use of a flow control system. This type of installation is illustrated diagramatically in Fig. 5.

Additional Bleed

4. The Combination of Methods of 1 and 3. This system has been used successfully on various installations and has the advantage that it can easily be incorporated with existing equipment. It will be seen from Fig. 6 that the Selas air gas ratio equipment operates in the conventional manner but that an additional bleed is taken from the gas line and injected on the inlet to the air compressor. This air compressor has an inlet suction of approximately 2½ in. w.g. The Wobbe Index is adjusted by variation in the rate of flow of gas by-passed around the mixing valve. It has the advantage that the full turndown range of the mixing machine is utilised for load changes and that this range is enhanced to provide compensation for fluctuations in Wobbe Index. There are two main applications of the control of Wobbe Index which are of particular interest to the gas industry.

1. The control of flame characteristics for direct heating application. A good example of this occurs in the manufacture of electric lamps. Variation in quality of gas supplied can lead to considerable difficulty since at different stages of manufacture various glass blowing operations are performed and some of these are extremely intricate. Any change in flame characteristic would therefore be serious; if the flame shortens some loss of heat would result and consequently the glass would not become sufficiently plastic for the operation to be carried out satisfactorily. If the flame lengthens, overheating and distortion will occur. The feed of components is continuous and controlled mechanically so that any spoiled work would not normally be detected until final operations are completed and the equipment undergoes test. As referred to earlier, extremely high throughput rates are often encountered and this would result in a high proportion of rejects.

Cone Height

Some trials have therefore already been carried out and the results of these trials already reported.[2] In brief, several methods of control were examined and one of these methods used cone height as the primary detection device. A certain degree of success was obtained but the trials indicated that the control of flame height is not a complete answer to variation in gas characteristics. After Wobbe Index control was applied as described under method 4 (Fig. 6), it was established that it is as successful as cone height control on some applications but also offered a marked improvement on others. Wobbe Index control at a glass bulb manufacturing plant by method 1 (Fig. 3) made complete flame stability possible. Other reports confirm these results and further particulars were given by A. H. Bird[3]. By

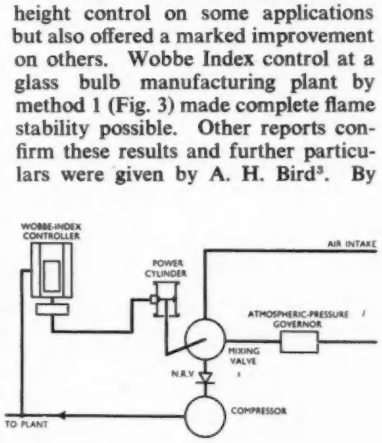


Fig. 5.

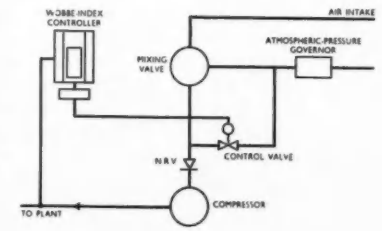


Fig. 6.

controlling the Wobbe Index of gas supplied to glass working plant, therefore, troubles which are the result of changing gas characteristic may be reduced to an acceptable level, if not entirely eliminated. The equipment can also be applied to similar direct flame applications, *i.e.*, local hardening processes, yarn gassing, etc. It may also be of application if use of the newly introduced method of thread gassing increases.

Surface Condition

2. Atmosphere control. One of the major problems in modern heat treatment practice is to maintain the condition of metal surfaces during heat treatment. This is particularly important in the case of copper and copper alloys. Even a slightly oxidising atmosphere at the high temperatures attained during annealing of copper will lead to the formation of red cuprous oxide; at the same time amounts of hydrogen in excess of 1% cannot be tolerated in tough pitch copper since they will reduce the cuprous oxide giving rise to embrittlement and blistering. As a result there has been a tendency towards furnaces with purified burnt town gas atmosphere for final annealing. At this stage the final appearance of the work is also controlled and consequently expensive pickling and cleaning methods can be avoided by close regulation of the furnace atmosphere. The need to maintain appearance during earlier stages is not so pronounced however, and recent trends have been to employ the natural combustion atmosphere to protect the change from oxidation and keep it clean. The choice of fuel is influenced by the atmosphere requirements and town gas has been successfully applied although it is usually necessary to remove sulphur in order to avoid staining caused by the presence of SO_2 and hydrogen sulphide in the furnace atmosphere. The proportion of sulphur dioxide and hydrogen sulphide formed from any sulphur remaining depends upon the air/gas ratio employed; consequently this is chosen to give a greater predominance of sulphur dioxide which reacts to a smaller extent and consequently the sulphur staining is reduced. Fig. 7 indicates the effect of changes in air/gas ratio upon the constituent gases present in a furnace atmosphere[4]. It is apparent that the flow of gas for the air/gas ratio control systems described will be affected by specific gravity changes and consequently the Wobbe Index has been suggested as a means of controlling furnace atmospheres.

Table 1 indicates[5] that for complete

TABLE 1

	Horizontal retorts	C.V.R., no steaming	C.V.R., steaming	Coke oven gas, debenzolised	C.W.G.	Oil gas
Calorific value at standard temperature and pressure sat., B.t.u. per cu. ft.	499·3	482·2	426·4	466·9	458·1	1,084·5
Air requirements, vol./vol. ..	4·908	4·708	4·06	4·572	4·270	10·936
Calorific value of theoretical mixture, B.t.u. per cu. ft. ..	84·5	84·5	84·3	83·8	86·9	90·9
Specific gravity of gas ..	·40	·43	·48	·38	·68	·68
Wobbe Index of theoretical mixture B.t.u. per cu. ft. ..	89·2	89·2	89	89	90·1	92

Wobbe Index for theoretically correct air/gas/ ratio.

combustion of gases normally found in grid systems, the Wobbe Index is substantially constant. If this is maintained to a steady value therefore it is reasonable to believe that the atmosphere can be held within desired limits and certainly to within much closer tolerance than would be the case if hand regulation were employed. Obviously this will not be an absolute control but will be of the open-loop type already referred to.

Confirmed

This principle of operation has now been confirmed by trials carried out on a direct fired controlled atmosphere annealing furnace. Records obtained during the trials are shown in Fig. 8; A shows the changes in Wobbe Index of gas supply; B the controlled value after dilution with air, and C the effect upon the CO and H_2 present in the furnace atmosphere. Control was based on the use of a signal from a Wobbe Index controller taking a sample from the mixed air/gas main, to modify the air/gas ratio control circuit. The resulting stability of the CO and H_2 content of the atmosphere gases is definitely attributable to the application of Wobbe Index control as prior to its installation, furnace atmosphere variations coincided with changes in gas characteristics.

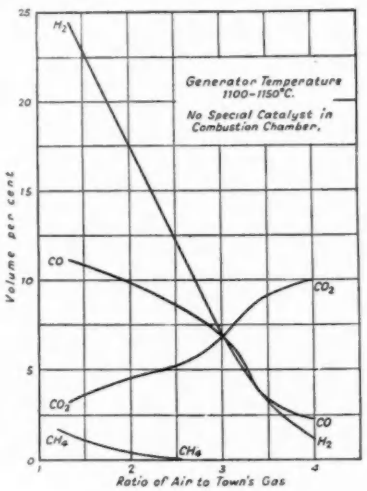


Fig. 7.

The results obtained on this installation have been confirmed by an installation in the Eastern Gas Board area but other plant difficulties have prevented the compilation of test data. However, the similarity in results indicate the stabilisation of Wobbe Index of gas supply is an important step towards eliminating variation in atmosphere control and further work will show whether this pattern is sustained.

Optimum Efficiency

The above applications, one direct and the other inferential, indicate that Wobbe Index control can be supplied to solve problems in widely differing spheres but clearly a complete answer to all gas utilisation problems is not obtained by this means. The importance of pressure control cannot be stressed too highly and furthermore the experience of industrial sales engineers is of great value in ensuring that industrial consumers obtain the optimum efficiency from their plant.

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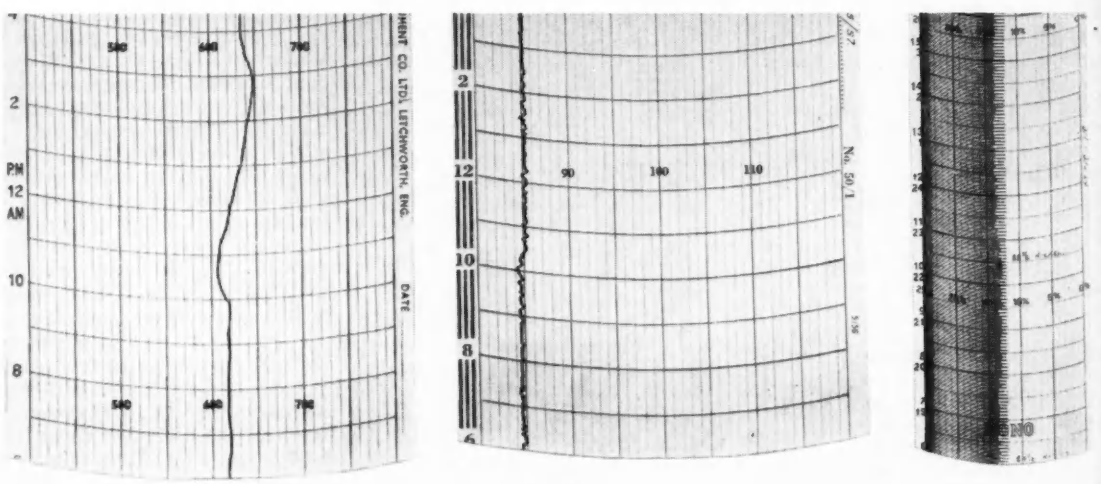

Fig. 8.